Remarks on Heat Transfer in Future PFCs

Some thoughts on the future

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Remark 1: It will happen!

So let us consider work on heat transfer for US PFC effort.

Liquid Surface:

- **NSTX/CDXU (ALIST)**
- **Liquid surface PFCs, div. integration (APEX)**
- **Other liquid surface applications (?)**

He, molten salt, liquid metal:

Water:

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He, molten salt, liquid metal:	• **He-cooled systems (APEX IV, SNL test/dev.)** • **First wall for ITER TBM** • **He-cooled or LM-cooled armor or probes (?)**

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Water:	• **W rod armor designs for ITER/FIRE (base)** • **First wall for ITER (US ITER procurement)** • **Current & near term devices, e.g., guard limiters and armor for RF antennae, … (?)**

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Remark 2: What are the prospects?

For Liquid Surface Systems

- **NSTX/CDXU** **ALIST work will continue on a lithium module for pumping.**

  NSTX also has heat management issues!

- **APEX** **1. Work in Task 3 will stop on divertor integration!**

  2. Further LM experiments in MTOR (?) may apply to divertors.

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  2. Further LM experiments in MTOR may apply to divertors.

  A new PFC collaboration using MTOR may make sense.
  We will need to define this collaboration.

- **Others interested in LS PFCs** (Mike Ulrickson has inquired abroad.)

  KFA LM program continues but at a lower level than in past.

  The Tore Supra Team has a small continuing interest.

  Japan has interest in IFMIF plus other LM work.

  C-MOD has expressed some interest in the past.

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Remark 3: What are the prospects?

For Helium Cooled Systems

- **SBIR He-cooled (fusion) modules have made major breakthroughs, but there is no further work! Some non-fusion development continues.**

  Ligamentary (porous) structures would likely improve heat transfer and tritium release in Be beds and solid breeders. The US is not positioned (or disposed) to use this US technology to advantage.

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- **US will evaluate choices for its ITER TBM. The likely choices, Flinabe or Li-Pb, will have He-cooled FS first walls (but with Be for ITER FW).**

  PFC collaboration on the FW for the US TBM is a good way to proceed. We need to define this collaboration. This may be the best (or only) way for the US program to maintain capability in advanced PFCs.

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For Helium Cooled Systems

- **SBIR work has led to major breakthroughs in He-cooled mockups. There is no further SBIR work; some non-fusion development continues.**

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- **US will evaluate choices for its ITER TBM. The likely choices, Flinabe or Li-Pb, will have He-cooled FS first walls.**

  The *PFC program needs to define an active collaboration on the FW for the US TBM is a good way to proceed. This may be the best (or only) way for the US program to maintain capability in advanced PFCs.*

- **He-cooled armor or probes could enable upgraded hardware in currently operating devices as power levels and pulse lengths increase.**

  Confinement projects do not have the expertise for such development. The PFC program does.

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Remark 4: What are the prospects?

For Water Cooled Systems

Three main efforts – Tore Supra, JET and ITER:

1. **CEA (+US) developed/deployed water cooled limiters for Tore Supra and has had a strong development program for ITER PFCs.**
   The CIEL is designed and partially installed (R&D done).
2. **The EU (+US) developed water-cooled divertor elements for JET and has had a strong supporting development program for ITER PFCs.**
   Water-cooled PFCs were not installed in JET (R&D done).
3. **The EU/RF/Japan (+US lab & industry) developed a water-cooled divertor for ITER. The US designed a water-cooled divertor for FIRE.**

Despite world-wide recognition of US expertise, the US is not a party to the ITER divertor procurement.

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Remark 4: What are the prospects?

For Refractory Armor Systems

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Three areas of past US interest in W armor:

1. **Development and testing W rod armor for the ITER and FIRE divertors.**
   The US commitment to ITER will not include work on the divertor.
2. **He cooled designs for DEMO (advanced nano-dispersoid W alloys)**
   It is not yet clear what US activity will support further R&D.
3. **W armor for the C-MOD divertor (passive cooling)**
   Sandia has worked with MIT on design development. MIT wants to reduce the cost of the design and perhaps deploy some trial armor.

   An upgrade to a W divertor would be quite expensive.

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Remark 5: Carpe annum!

Reconsider work in heat transfer for a vital US PFC program.

Liquid Surface:	• **Continue MHD model development and some heat transfer analysis in ALIST work.** • **Continue some MHD analysis for DiMES.** • **Continue low level of effort on exchange of information on liquid surface applications.**
He, molten salt, liquid metal:	• **Define active PFC role in ITER TBM FW development.** • **Take lead (propose subgroup) on TBM diagnostics.** • **Encourage SBIR development in He-cooled systems.** • **Develop He-cooled or LM-cooled probe/armor.**
Water:	• **Advise procurement activity for ITER FW.** • **Collaborate with Japan on W rod armor designs.**
Other:	• **Collaborate on AFS & advanced W HHF tests.**

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